The occlusal index: A system for identifying and scoring occlusal disorders

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Whereas several investigators[1-9] have attempted to measure occlusion for epidemiologic purposes, there is no generally acceptable method. Variations in *terminology, concepts,* and *methodology* can be cited as the major reasons for the present lack of a universally acceptable index of occlusion. For these reasons, a study was undertaken to attempt to develop an index of occlusion. This index is called the occlusal index (OI).

Terminology

The word *occlusion* is an imprecise word, generally used in an imprecise way. It has an acceptable definition: "The manner in which the teeth intercuspate."[10] The word *malocclusion*, however, is an imprecise word, improperly used in a precise way. It has a "wide divergence" in definition.[11] The word *malocclusion* is commonly used in describing the prevalence of occlusal disorders. The prevalence of malocclusion as reported from nine different investigations is presented graphically in Fig. 1. The variation in reporting is obvious. While the size, age, sex, and geographic location of the samples might be considered as contributory, lack of an adequate definition of malocclusion is probably a main factor in this variation. Each investigator seems to interpret mlocclusion as an invariable state (that is, either you have a malocclusion or you don't) rather than a continuum of many variables. Such terms as *normal occlusion* and *acceptable occlusion* are sometimes used to describe occlusal status, but, like *malocclusion*, they are inadequately defined and thus lack precision.

Epidemiologically, the word *occlusion* is preferred, because it encompasses all

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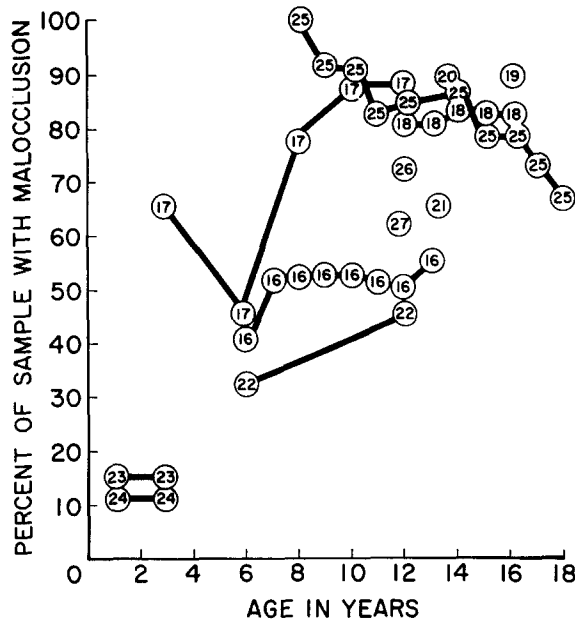
Fig. 1. Prevalence of malocclusion as reported from nine different investigations after 1955. Numbers refer to the following sources: **16,** Newman, 1956.[12] **17,** Burlington Orthodontic Research Centre, 1958.[13] **18,** Altemus, 1959.[14] **19,** Van Kirk and Pennell, 1959.[9] **20,** Ast, Allaway, and Draker, 1962 (Kingston).[15] **21,** Ast, Allaway, and Draker, 1962 (Newburg).[15] **22,** Emrich, Brodie, and Blayney, 1965.[16] **23,** Tank and Storvick, 1965 (Albany).[17] **24,** Tank and Storvick, 1965 (Corvallis).[17] **25,** Mills, 1965.[11] **26,** Erickson and Graziano, 1966 (Greensboro).[18] **27,** Erickson and Graziano, 1966 (High Point).[18]

variations (good occlusion to malocclusion) and implies continuous variability; the investigator is free to designate degrees of occlusion rather than just the invariable state (malocclusion).

The term *occlusal disorder* will be used throughout this article and will mean any variation in occlusion which is unacceptable esthetically or functionally to either the person with the occlusion or the examining dentist. Whereas this term is not precise and, etymologically, is not better than the word *malocclusion*, it does not carry the preconception of malocclusion and it does convey variability rather than an invariable state.

Concepts

The requirements for all dental indices have been summarized in a World Health Organization report,[19] and the following main requirements for an index of occlusion will be discussed in detail:

1. *Reliability.* The index should be reproducible by other examiners or by the same examiner at some other point in time.
2. *Validity (per se).* The index should measure what it was intended to measure.
3. *Validity during time.*[20] The index should consider the normal development of occlusion.
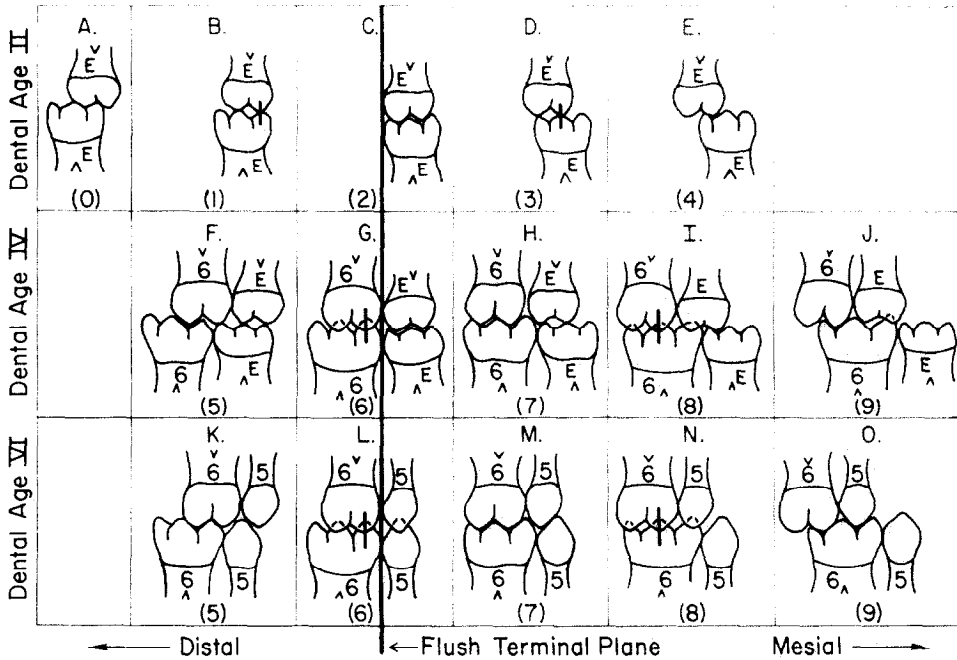
Fig. 2. Occlusal index, scoring of molar relation. Numbers in parentheses are the OI codes for molar relation.

An explanation of validity during time is in order. Because developmental changes in occlusal disorders may consist of either a basic *orthodontic defect* or a *symptom* of a developmental change, the index must concentrate on, and be sensitive to, the basic orthodontic defect and must not be unduly sensitive to the symptom.

A basic orthodontic defect may be defined as a constant occlusal dysfunction which may exist before, during, and after the development of occlusion. This defect may be (1) skeletal, such as a mandible disproportionate in size to the maxilla; (2) dental, such as a discrepancy in the size of the teeth and the jaw; or (3) neuromuscular, such as a tongue-thrust.

The basic orthodontic defect usually is present before the development of occlusion, although it may not become manifest until after the mixed-dentition stage. As an example, a skeletal Class II malocclusion at age 7 is still a skeletal Class II malocclusion at age 16, and yet it was present at age 2.

A symptom of a developmental defect may be defined as an adaptation to development; this change may be an accommodation either to normal growth or to a basic orthodontic defect. The symptom may either be constant (present at all ages) or variable (fluctuating with age). An example of a symptom is the flaring and spacing of the maxillary permanent incisors normally seen in the early mixed dentition.

By definition, then, for an index of occlusion to be valid during time, the index score for the occlusal disorder should either remain constant or increase during time (indicating that the occlusal disorder is the same or getting worse). The index score should not decrease during time (indicating that the

occlusal disorder is getting better). "While mention frequently is made in the literature of self-correction of malocclusion, when the distinction is made between stages of growth and developing malocclusion, there actually are few instances of self-corrected malocclusion."[21]

Methods in scoring

Nine characteristics are scored in the occlusal index: dental age, molar relation, overbite, overjet, posterior cross-bite, posterior open-bite, tooth displacement (actual and potential), midline relations, and missing permanent teeth.

The purposes of describing these scoring procedures in detail are as follows:

1. To standardize scoring procedures so that comparable results may be obtained among investigators.
2. To indicate how each scoring procedure is mutually exclusive; double scoring is eliminated, as in the common example of a displaced posterior tooth which can be scored as a displaced tooth and also scored as a tooth in cross-bite.
3. To enable investigators to apply subjective classifications to the objective measurements, if needed for broad comparisons at a later point in time.

Scoring of nine characteristics

Dental age. By classifying the occlusion into a dental age, based on the stage of occlusal development, differences in chronologic age, sex, and sequence of tooth eruption are corrected:

1. *Dental age 0* begins at birth and ends with the eruption (appearance of any portion of the clinical crown) of the first deciduous tooth. This dental age is characterized by having no erupted teeth.
2. *Dental age I* begins with the eruption of the first deciduous tooth and ends when all deciduous teeth are in occlusion. This dental age is characterized by the development of the deciduous dentition.
3. *Dental age II* begins when all deciduous teeth are in occlusion and ends with the eruption of the first permanent tooth. This dental age is characterized by the presence of the completed deciduous dentition.
4. *Dental age III* begins with the eruption of the first permanent tooth and ends when all permanent central and lateral incisors and first molars are in occlusion. This dental age is characterized by the first stage of the mixed dentition, sometimes referred to as the "early mixed dentition."
5. *Dental age IV* begins when all permanent central and lateral incisors and first molars are in occlusion and ends with the eruption of any permanent canine or premolar. This dental age, which is characterized by a "dormant" period during which no permanent teeth are erupting, is sometimes referred to as the "middle mixed dentition."
6. *Dental age V* begins with the eruption of any permanent canine or premolar and ends when all the permanent canines and premolars are

in occlusion. This dental age is characterized by the last stage of the mixed dentition, sometimes referred to as the "late mixed dentition."

7. *Dental age VI* begins when all permanent canines and bicuspids are in occlusion. This dental age is characterized by the presence of the completed permanent dentition (second molars may or may not have erupted).

Second permanent molars are not considered in the assessment of dental age, inasmuch as canines and premolars usually erupt before second molars and fix the anteroposterior position of the first permanent molars. Subsequent eruption of the second molars, therefore, usually has no effect on molar relation.

Several of the described dental ages either begin or end when groups of teeth have completely erupted into occlusion. Occlusal contact, however, does not occur in the child who has an open-bite or in whom one or more teeth, for a variety of reasons, have failed to erupt to the occlusal plane. When extenuating circumstances, such as sucking habits or tongue-thrusting, have produced the lack of occlusal contact, the mere presence in the mouth of the required teeth for a specific dental age is used in making the assessment.

Molar relation. The scoring of molar relation has the following properties[3]:

1. Defined "cut-off" points, where one type of relation ends and another begins.
2. No classification into Angle Class I, II, or III; Angle's classification, however, may be derived from these measurements.
3. The relation of the deciduous second (E) and permanent first molars (6) is considered for each side.

Five relations each for the deciduous and permanent molars were used. This is best described by considering dental age II (for the relation of E) and dental age VI (for the relation of 6), as shown in Fig. 2, *A* through *E* and *K* through *O*.

Morphologically, E and 6 are similar, except that E is smaller than 6. The "cut-off" points are as follows:

A. Deciduous teeth
    1. Mesial. The mesiobuccal cusp of E occludes with the distobuccal cusp of Ē, as shown in Fig. 2, *D*.
   2. Distal. The mesiobuccal cusp of E occludes with the mesiobuccal cusp of Ē, as shown in Fig. 2, *B*.

B. Permanent teeth
    1. Mesial. The mesiobuccal cusp of 6 occludes with the distobuccal cusp of 6, as shown in Fig. 2, *N*.
    2. Distal. The mesiobuccal cusp of 6 occludes with the mesiobuccal cusp of 6, as shown in Fig. 2, *L*. The flush terminal plane* also occurs when these cusps are vertical; the flush terminal plane can be used to score "cusp to cusp," distal of 6, because the plane is more easily visualized and its position is determined from a normal E relation.

When both dental age and molar relation are considered, normal molar rela-

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*Flush terminal plane is formed when the distal surfaces of E and/or the mesial surfaces of 6 are vertical.

Table I. Occlusal index, scoring and code for molar relation

Molar	Code	Illustrated in Fig. 2	Molar relation
1 ⟨ E / 6	(0) / (5)	A / K	> Cusp to cusp, distally
2 ⟨ E / 6	(1) / (6)	B / L	Cusp to cusp, distally; flush terminal plane
3 ⟨ E / 6	(2) / (7)	C / M	< Cusp to cusp, either mesially or distally; normal relation
4 ⟨ E / 6	(3) / (8)	D / N	Cusp to cusp, mesially
5 ⟨ E / 6	(4) / (9)	E / O	> Cusp to cusp, mesially

tion in one age may be abnormal in another age; consider Fig. 2, *G* and *L*. With these "cut-off" points, five relations for both deciduous and permanent molar relation result. These relations are summarized in Table I.

Overbite. Overbite is scored as the vertical distance from the incisal edge of the maxillary central incisor to the incisal edge of the mandibular central incisor when the jaws are in "centric occlusion." Positive overbite is scored as the distance the maxillary central incisor occludes past the mandibular central incisor, and this distance is scored in "thirds" of the length of the clinical crown of the mandibular central incisor. Negative overbite (open-bite) is scored as the vertical distance from the incisal edge of the maxillary central incisor to the incisal edge of the mandibular central incisor in millimeters.

Overjet. Overjet is scored as the horizontal distance from the labial surface of the maxillary central incisor to the labial surface of the mandibular central incisor in millimeters. The scores may be positive, zero, or negative.

Posterior cross-bite (osseous type). Cross-bite may be dental, functional, or osseous.[22] Therefore, in order for posterior cross-bite to be an indicator of the osseous relation, it must be differentiated from other types of cross-bite.

Dental cross-bite usually involves a tipping of one tooth as a result of space insufficiency. The condition is localized and does not affect the size or shape of the basal bone. In dental cross-bite this tooth will not be in normal arch alignment and will be scored as a displaced tooth rather than a cross-bite.

Functional cross-bite involves muscular adjustment to tooth interferences. The teeth seem to be in normal arch alignment, but the lower jaw will not close without shifting, thereby causing the functional cross-bite.
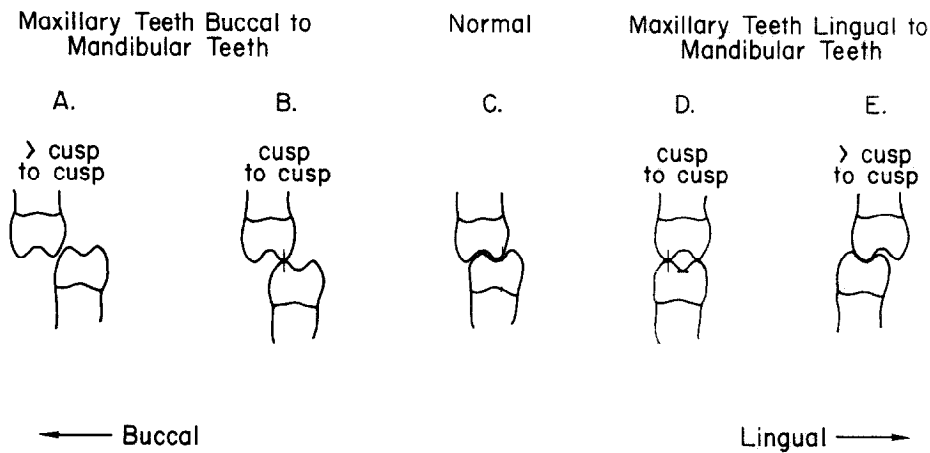
Maxillary Teeth Buccal to
Mandibular Teeth

Normal

Maxillary Teeth Lingual to
Mandibular Teeth

A.

B.

C.

D.

E.

⟩ cusp
to cusp

cusp
to cusp

cusp
to cusp

⟩ cusp
to cusp

◄—— Buccal

Lingual ——►

Fig. 3. Occlusal index, scoring of posterior cross-bite.

Osseous cross-bite involves a gross mesiolateral disharmony of the craniofacial skeleton. All teeth seem to be in normal arch alignment. When a single tooth is involved, it is usually the most posterior molar; the premolars are in osseous cross-bite only when the molars are also in cross-bite. Cross-bite may be unilateral or bilateral and is scored similarly to molar relation, in that posterior cross-bite has definite "cut-off" points and can assume five cuspal relations, as illustrated in Fig. 3. The buccal cusp of the mandibular posterior tooth is used as the cusp which determines the posterior cross-bite cuspal relation.

Posterior cross-bite is scored the same for the deciduous, mixed, or permanent dentitions; that is, one counts the number of teeth in the maxillary arch which are in each type of posterior cross-bite cuspal relation.

Posterior open-bite. Posterior open-bite may be defined as the lack of occlusal contact between any opposing posterior teeth (posterior teeth include the deciduous canines and molars, and the permanent canines, premolars, and molars) with the jaws in "centric occlusion." Posterior open-bite may be unilateral or bilateral and may accompany an anterior open-bite (negative overbite). Posterior open-bite is scored as either present or not present and, if present, as either unilateral or bilateral. Generally, two or more adjacent posterior teeth will be in open-bite.

Tooth displacement. The scoring procedures for tooth displacement will be discussed by dividing the dentitions into the nonmixed (deciduous and permanent) and mixed dentitions.

NONMIXED DENTITIONS. The scoring of tooth displacement for the nonmixed dentition includes two degrees of displacement[9]: (1) 1.5 to 2.0 mm. deviation or 35 to 45 degrees of rotation from normal arch alignment (scored as 1 or single weight) and (2) > 2 mm. deviation or > 45 degrees of rotation from normal arch alignment (scored as 2 or double weight).

Premolars and molars are not scored for rotation in the occlusal index. A tooth may be in normal arch alignment buccolingually, but, because of space deficiency, it may be blocked by the adjacent teeth and fail to erupt completely.

A tooth in this situation is sometimes referred to as being in infraversion and is scored as "1.5 to 2.0 mm. deviation."

MIXED DENTITION. Tooth displacement in the mixed dentition can be divided into two types, depending on the cause.

1. Tooth displacement not associated with space deficiency. A displaced tooth not associated with space deficiency is any maxillary or mandibular incisor or canine which is displaced (either deviated 1.5 mm. or more or rotated 35 degrees or more) when, at the same time, there is sufficient space in the arch line for normal alignment. Causes of this type of displacement are usually habits or eruption disorders. These teeth are weighted (1 or 2), as in the displacement scoring procedures for the nonmixed dentitions.

2. Tooth displacement associated with space deficiency. During the mixed dentition, if the space necessary for proper adjustment of the completed permanent dentition is known, probable tooth displacement may be predicted. A method of assessing potential space deficiency is to measure the mesiodistal widths of the permanent teeth and subtract the length of the arch perimeter. If the width of the teeth exceeds the arch perimeter, tooth displacement will occur. The mesiodistal widths of some permanent teeth, however, are unknown during the mixed dentition.

   One available method, the mixed dentition analysis (MDA),[22] can predict the mesiodistal widths of the canines and premolars with certain degrees of probability from measurements of the mesiodistal widths of the mandibular permanent incisors. By subtracting the predicted widths of the canines and premolars from the available space, one can estimate the expected amount of tooth displacement. Preliminary studies indicate that n + 1 mm. of space deficiency produce n displaced teeth. This information is factored into the weighting mechanism of the occlusal index to make the index valid over time. When an occlusion is scored during the mixed dentition and a space deficiency is noted, the weighted value for the space deficiency will be similar to the weighted value for tooth displacement which the occlusion will have when examined during the permanent dentition.

   The procedure for scoring tooth displacement associated with space deficiency is as follows (all measurements are in millimeters):

   (a) Measure the greatest mesiodistal width of each of the four permanent mandibular incisors; divide the total of the sum of the widths by 2.

   For each quadrant:

   (b) Add 10 to the sum in (a), if measuring the maxillary quadrants, or add 9 to the sum in (a), if measuring the mandibular quadrants.

   (c) Determine any mandibular incisor overlap in millimeters and add this value to the sum in (b) ; if there is no incisor overlap, measure any spacing between the mandibular incisors in millimeters and subtract this value from the sum in (b).

	Quadrant	Incisor overlap	Space	Arch length: mesial of the lateral to distal of the 1st permanent molar
½ of the width of the 4 lower **plus** incisors ——— mm.	10 upper left	(+) or	(-)	— ( ) = ———
	upper right	(+) or	(-)	— ( ) = ———
	9 lower left	(+) or	(-)	— ( ) = ———
	lower right	(+) or	(-)	— ( ) = ———

Add positive scores only. Total = ———

Fig. 4. Occlusal index, scoring of the mixed-dentition analysis.

(d) Measure the arch length from the distal surface of the permanent lateral incisor to the mesial surface of the first permanent molar; subtract this from the score in (c).

(e) Repeat steps (b) through (d) for each quadrant.

(f) Add the positive scores in (d) from each quadrant. The final score is the total estimated amount of space deficiency, in millimeters. This score will be "weighted" in the computation of the OI score.

This procedure is formulated in Fig. 4.

Midline relations.

DIASTEMA. A midline diastema is defined as the space, in millimeters, between the two maxillary central incisors, either deciduous or permanent, which have erupted into occlusion. If the incisors are not in occlusion (dental age III), the observation is not recorded. When the diastema equals or exceeds 2 mm., it is given a weight in the OI.

JAW DEVIATION. Midline jaw deviation is defined as the distance, in millimeters, between the midpoint of the two maxillary central incisors and the midpoint of the two mandibular central incisors in the horizontal (occlusal) plane when the teeth are in centric occlusion. If any central incisor is missing, the procedure is not recorded. Jaw deviations of 3 mm. or more are given a weight in the OI.

Missing permanent teeth. Only missing maxillary incisor teeth which have not been replaced by a prosthesis are scored. Normally, in a child with at least any four of the twelve permanent canines or premolars in occlusion all incisors should be erupted. After this stage of dental development, measurement can be made. One simply records the number of missing maxillary incisors.

Calculating forms of the occlusal index (OI)

In keeping with the concept of validity during time, an index of occlusion should consider the stages of dental development. The OI incorporates separate weighting mechanisms for each stage:

1. Deciduous dentition stage—dental ages I and II.

2. Mixed-dentition stage—dental ages III, IV, and V.

3. Permanent dentition stage—dental age VI.

EXAMINATION: ITEM AND CODE If 6's are not in occlusion, go to item 2A and 3A					OCCLUSAL SYNDROME						
					I&II					III	
					A	B	C	D	E	F	G

MIXED DENTITION ANALYSIS — incisor overlap or space — distal of the lateral to mesial of 1st molar

$\frac{1}{2}$ the width of the 4 lower incisors

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        UL (+    ) or (-    ) - (    ) = _____
  .10   UR (+  . ) or (-    ) - (    ) = _____
   9    LL (+    ) or (-    ) - (    ) = _____
        LR (+    ) or (-    ) - (    ) = _____
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_____ mm. plus

Code the Total: Add positive scores only: Total = _____

1. (I&II and III have the same code)	Total	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Code	0	0	2	3	4	5	6	7	8.0	8.6	9.3	10.0	10.6	11.3	12.0	12.6

MOLAR RELATION (of 6) Mesial Migration?	Normal	1 side c to c	2 sides c to c	1 side +	1 side c to c & 1 side +	2 sides +
2. DISTAL	0	0.0	0.0	1.0	1.5	3.2
3. MESIAL	0	2.0	2.3	2.5	2.9	4.0

MOLAR RELATION (of e)	Normal	1 side c to c	2 sides c to c or 1 side +	1 side c to c & 1 side +	2 sides +
2A. DISTAL	0	1.5	2.2	2.9	3.7
3A. MESIAL	0	2.0	2.6	2.9	4.0

4. If the molar relation is NORMAL or DISTAL, circle I&II; if the molar relation is MESIAL, circle III. If III is circled, all item codes must be entered under III.

OVERJET (in mm.)	<-3	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	>+11
5. I&II	2.2	2.0	1.8	1.4	1.0	1.5	0	0	0.5	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3
I&II	4.0	3.5	3.0	2.5	2.1	1.7	0	0	1.1	1.9	2.6	3.4	4.1	4.8	5.6	6.5	7.4
6. III	6.7	6.1	5.9	5.6	3.4	2.2	0	0	0								

OVERBITE (in mm.)	<-4	-4 to -2	-2 to 0	(relation of upper incisor to lower incisor				
				0 to 1/3	1/3 to 2/3	2/3 to 3/3	3/3	>3/3
7. I&II	4.5	4.0	3.6					
8. I&II				0	1.3	2.3	3.7	5.0
9. III				0	0.8	1.8	2.7	3.9

CONGENITALLY MISSING INCISORS	Number	0	1	2	3 or 4
10. I&II	Code	0	5.4	6.5	8.0

POSTERIOR CROSSBITE

Count the number of upper posterior teeth which are BUCCAL to the lower teeth

11.		0	1	2	3	4	5	6	7	8
I&II	(c to c)	0	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5
I&II	(>c to c)	0	1.5	2.9	2.5	3.5	4.0	5.0		

Count the number of upper posterior teeth which are LINGUAL to the lower teeth

12.		0	1	2	3	4	5	6
I&II	(c to c)	0	0.7	0.8	1.0	1.1	1.4	1.6
I&II	(>c to c)	0	1.5	1.8	2.0	2.5	2.8	3.0
13. III	(c to c)	0	1.2	1.4	1.7	2.0	2.5	3.0
III	(>c to c)	0	2.2	2.4	2.7	3.0	3.5	4.0

POSTERIOR OPENBITE

There must be at least two teeth in the same quadrant which are in openbite	14. I&II	unilateral	bilateral
		3.0	4.2

TOOTH DISPLACEMENT (According to the tooth displacement rules)
Count the number of teeth which are:

rotated 35-45° or
deviated 1.5-2 mm. _____ + deviated > 2 mm. _____ X 2 = _____ Total

rotated >45° or

(I&II and III have the same code)	0	1	2	3	4	5	6	7	8	9	10 or more
15. Code the Total	0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	8.6	9.3	10.0

MIDLINE DIASTEMA (in mm.) (I&II and III have the same code)	16.	0 to 1	2	3	4 or more
		0	0.5	1.0	1.5

MIDLINE DEVIATION (in mm.) (I&II and III have the same code)	17.	0 to 2	3 to 4	5 or more
		0	0.5	1.5

18. TOTAL SCORE FOR THE OCCLUSAL INDEX ————————————————————————————→

19. If I&II were circled, ADD the HIGHEST score (A,B,C,D,E) plus $\frac{1}{2}$ of the remaining scores ————————

20. If III was circled, ADD the HIGHEST score (F or G) plus $\frac{1}{2}$ of the remaining scores

Fig. 5. Occlusal index, calculating form. Dental ages III, IV, and V, mixed-dentition.

An example of the calculating form which contains the weights for the mixed-dentition stage is given in Fig. 5.*

*Space limitations prohibit publication of the calculating forms for the other two stages. Copies of a syllabus containing these forms and a short form specifically designed for surveys are available from the author.

The OI contains two divisions and seven syndromes. The examination item number is given in parentheses.

Divisions I and II* (normal or distal molar relation)

Syndrome A. Overjet (5) and open-bite (7).

Syndrome B. Distal molar relation (2), overjet (5), overbite (8), posterior cross-bite (11 and 12), midline diastema (16), and midline deviation (17).

Syndrome C. Congenitally missing incisors (10).

Syndrome D. Potential tooth displacement (1) and tooth displacement (15).

Syndrome E. Posterior open-bite (14).

Division III (mesial molar relation)

Syndrome F. Mesial molar relation (3), overjet (6), overbite (9), posterior cross-bite (13), midline diastema (16), and midline deviation (17).

Syndrome G. Mixed-dentition analysis (1) and tooth displacement (15).

These syndromes were designed after those of Grainger[3, 23] in the Treatment Priority Index (TPI) and its predecessor, the Malocclusion Severity Estimate (MSE) of the Burlington Orthodontic Research Centre.

The calculating form to be used is determined by the dental age of the subject. After the dental age is ascertained, the appropriate form can be used. One simply scores each examination item (Nos. 1 to 17), circles the score on the form (observation score), and places the weighted score (code) listed below the observation score in the appropriate column under the appropriate occlusal syndrome. The sum of the weights in all columns is then determined.

To arrive at the total score, it is necessary to ascertain molar relation. Then, the weights of all measurements will be placed in the syndromes of that division, and the score will be derived from only those syndromes. If Divisions I and II was circled, the score is the score of the syndrome with the highest score (either A, B, C, D, or E) plus one half of the total scores of the remaining syndromes. If Division III was circled, the score is the score of the syndrome with the highest score (either F or G) plus one half of the total score of the other syndrome. For example, if the molar relation were distal, Divisions I and II would be circled, and if the scores of syndromes were

Syndrome	A	B	C	D	E
Score	2.6	5.4	0.0	3.0	3.0

The OI score would be

$$\left(\begin{matrix} \text{Score of the syndrome with} \\ \text{the highest score} \end{matrix} \right) \quad \text{plus} \quad \left(\frac{\text{Sum of remaining syndrome scores}}{2} \right)$$

or

$$(5.4) + \left(\frac{2.6 + 0.0 + 3.0 + 3.0}{2} \right) = 5.4 + \frac{8.6}{2} = 9.7 \text{ Total OI score}$$

*Because of the usual symbolism associated with the Angle classification system, the divisions are categorized with similar connotations: Divisions I and II, like Classes I and II, has a normal or distal molar relation and Division III, like Class III, has a mesial molar relation.

Tests of validity, validity during time, and reliability

Two sources of dentofacial data (in the form of dental casts) were utilized to test the validity, validity during time, and intra-examiner reliability for this study:

1. *Sample I.* Cross-sectional data derived from the Tecumseh Community Health Study.[24, 25] This sample consisted of casts from sixty subjects who represented most types of occlusal disorders, in various stages of occlusal development, and of chronological ages 5 to 14.

2. *Sample II.* Serial data derived from The University of Michigan's Growth Study. In this sample each subject's set of casts contained annual casts from at least the ninth year of age to at least the sixteenth year of age. No subject in this sample had received orthodontic treatment. The ages 9 through 16 were chosen to include the entire mixed and permanent dentitions. A total of forty-seven subjects (thirty boys and seventeen girls) were found who met these criteria.

Validity. Validity was tested by comparing the OI scores of Sample I to a *clinical standard.* The clinical standard was derived by having six judges array the sixty casts from Sample I. The six judges consisted of five orthodontists, who were faculty members in the School of Dentistry, The University of Michigan, and had practiced orthodontics for an average of 7 years, and one public health dentist who was enrolled at the School of Public Health, The University of Michigan. These casts were arrayed according to the following criteria and their relative importance:

1. Esthetics   50 per cent
2. Function   35 per cent
3. Treatment difficulty 15 per cent

Agreement among the judges was tested by the Kendal Coefficient of Concordance, W, which equalled 0.881 (significant at $p < 0.001$). A high or significant value of W may be interpreted as meaning that the judges were applying essentially the same criteria in ranking the casts; consequently, their pooled ordering may serve as a standard.[26] It should also be noted that these same six judges reranked the same sixty sets of casts, and intrajudge reliability was very high. The average Spearman Rank Correlation Coefficient, r_s, was 0.903 (significant at $p < 0.001$).

After the casts from Sample I were scored for the OI, the scores were then ranked by increasing values. The Spearman Rank Correlation Coefficient was used to test the relation between the ranks of the OI and the ranks of the clinical standard. Because ties in ranks occurred, a tie-correction formulation was used.[26] There was a high correlation between the ranks of the standard and those of the OI: $r_s = 0.920$. A scattergram for this correlation is shown in Fig. 6. Two parallel lines, each ten units away from the center line, denote an arbitrary deviation of tolerance; fifty out of sixty points (85 per cent) lie within the lines of tolerance and denote the amount of strength of the relation.

Validity during time. Validity during time was tested by averaging the OI scores of the casts from Sample II and noting any change in the index score during time. If there was a decrease in the OI score during time, the index would be classified as unduly sensitive to the symptoms of a developmental defect
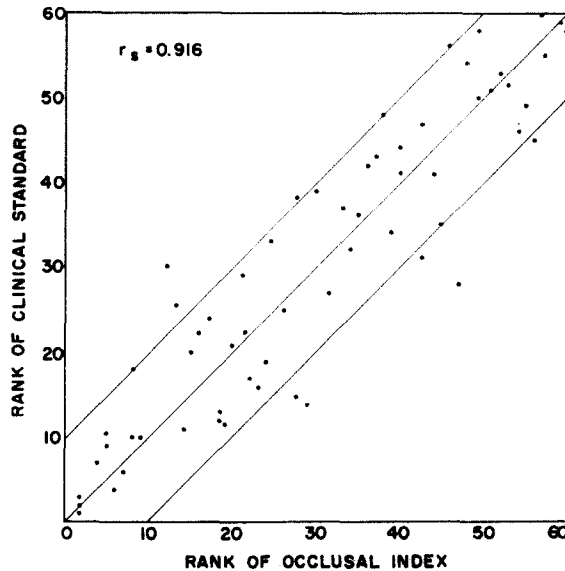
Fig. 6. Relation between the rankings of the clinical standard and the rankings of the occlusal index for sixty subjects (Sample I).

and as not concentrating on the basic defect, and thus not valid during time. A constant score or an increase in the OI score during time would indicate that the index was sensitive to the basic defect and thus could be classified as valid during time. The average OI scores by age and sex, utilizing serial data, are presented in Fig. 7. It should be noted that the scores increase, thus demonstrating the ability of the OI to be recording the basic defect as it becomes evinced.

Intra-examiner reliability. Intra-examiner reliability was tested by rescoring for the OI on the casts from Sample I one month after the original scoring. The scores were then reranked according to increasing values. The ranks of the original scoring were compared to the ranks of the second scoring by use of the Spearman Rank Correlation Coefficient, using tie correction. There was a high intra-examiner reliability for the OI: $r_s = 0.963$.

Interpretation of the occlusal index (OI) scores

After the judges had reranked the sixty sets of casts in the standard, they were asked to classify the rankings subjectively. The judges were not given any classification system to follow but were asked to classify the occlusions in any manner they wished. In addition, one judge classified 195 more casts that were not included in the standard.

The subjective classification resulted in the following classes:

1. Good occlusions—No evidence of an occlusal disorder.
2. No treatment—Slight deviations in the occlusion, but no treatment indicated at this time.
3. Minor treatment—Minor deviations in the occlusion which could be remedied by simple treatment (that is, space regainers or removable appliances).
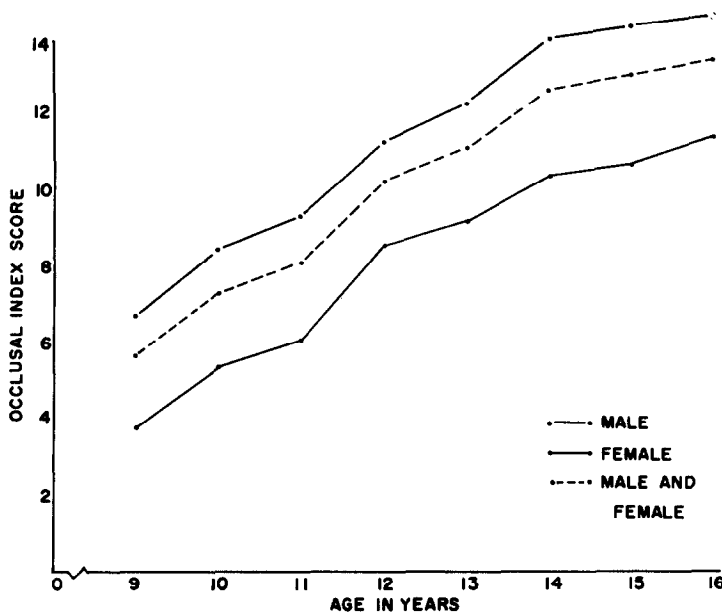
Fig. 7. Average occlusal index score, according to age and sex, for thirty male and seventeen female subjects, using serial data (Sample II).

Table II. Relation of the subjective classification of occlusion to the occlusal index scores

Class	*Suggested range of OI scores for class*
Good occlusions	0.0 to 2.5
No treatment	2.6 to 4.5
Minor treatment	4.6 to 7.0
Definite Treatment	7.0 to 11.0
Worst occlusions	11.1 to 16.0

4. Definite treatment—Major deviations in the occlusion which could be remedied by major treatment (that is, treatment which would include banding of many teeth).

5. Worst occlusions—Major deviations in the occlusion which could be remedied by major treatment; these occlusions were highly disfiguring to the patient and would probably rank first in treatment priority.

After the casts were measured according to the OI, the scores were matched against the judges' classification. Table II gives the relation of the subjective classification to the OI scores.

Summary

Because a lack of agreement prevails among investigators concerned with measuring occlusion for epidemiologic purposes, an attempt has been made to develop an index of occlusion which would serve for these purposes. This index was called the Occlusal Index (OI).

The methods of scoring the nine characteristics used in the OI have been presented. These characteristics included dental age, molar relation, overbite, overjet, posterior cross-bite, posterior open-bite, tooth displacement (actual and potential), midline relations, and missing permanent maxillary incisors. The scoring mechanism was briefly utilized.

The OI was tested for validity, validity during time, and intra-examiner reliability. The OI appears to correlate highly ($r_s = 0.920$) with the clinical standard, indicating high validity; the OI also appears to be valid during time, since the average group scores did not decrease during time. Intra-examiner reliability was very high ($r_s = 0.963$).

A subjective classification of occlusion which could be used to interpret the OI scores was devised. This subjective classification and a suggested range for each class were described.

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